FUNCTIONAL ASSEMBLAGES OF BIRDS IN HETEROGENEOUS LANDSCAPES ALONG AN URBAN-RURAL GRADIENT IN TIRUCHIRAPPALLI, INDIA

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As a result of urbanisation, landscapes and land use patterns are changing the world over. This extreme form of land use alteration has affected species composition and abundance, moulding a few species to dominate the urban environment and a few others to extinction. Urbanisation occurs at different scales and the community composition of species gets affected accordingly. In this paper, we look into species richness and abundance of birds, and their variation along an urban-rural gradient at Tiruchirappalli, India. In Tiruchirappalli, bird species diversity increases from more to less urbanised centres. Though diversity is less in urban areas, the abundance of species occupying these areas is higher. During this study, the maximum recorded birds were omnivores. The most affected species is the House Sparrow, with a few populations residing in the urban environment. Along the urban-rural gradient, farmlands and wetlands are the most preferred landscapes of birds, and conservation measures need to be oriented in this direction to protect the most vulnerable species. Species diversity in urban areas is significantly contributed to by edge species that occupy the fringes of urban areas. Though urban landscapes are less species rich, they too play a significant role in biodiversity conservation as they are species abundant zones. City planners and urban foresters need to pay more attention towards preserving habitats not only in urban areas but along the urban fringes, as they provide suitable corridors for various activities of birds and their movement.

Key words: urbanisation, abundance, richness, homogenization, ecosystem, biodiversity, communities

INTRODUCTION

Urbanisation often modifies landscapes and land use patterns, leading to changes in the vegetation and altering species composition. Urban ecosystems are characterised by low stability, complex and varied dynamics, abundance of exotic species, and different species composition (Machlis *et al.* 1997). Human domination of ecosystems leads to excessive consumption of resources (Turner *et al.* 1991), alteration of habitats and species composition (McKinney 2002), disruption of hydrological processes (Arnold and Gibbons 1996), and modification of energy flow and nutrient cycles (Grimm *et al.* 2000; Vitousek *et al.* 1997). Humans have modified the carbon cycle (Prentice 2001) to an extent that it has lead to the expulsion of large quantities of toxic gases into the atmosphere (Pacyna and Pacyna 2001). Urbanisation drives biotic homogenization (McKinney 2006; McKinney and Lockwood 1999) and it affects the communities found along an urban-rural gradient. When habitat heterogeneity decreases, landscapes often undergo homogenization, and similar species occupy these habitats causing extinction of the endemics (McKinney 2006; Olden 2006).

Studying faunal composition along an urban-rural gradient helps in understanding various ecosystem processes at landscape level. This is a unique area of research. In the concept of an urban-rural gradient, suburban habitats play a unique role in biodiversity conservation. These habitats can be ideal zones for birds and would contain half of the species found in forested areas if they are less exposed to developmental activities (Blair 2004) and high densities of birds in urban areas (Palomino and Carrascal 2006). Species richness peaks at the intermediate level of urbanisation (Tratalos *et al.* 2007). Some species thrive well in areas of high development, but certain other species are sensitive to various stress factors in the environment and are forced to extinction (Jackson 2006). Some prime factors that affect bird community composition and abundance along an urban-rural gradient include proximity to roads, developmental activities (Brotons and Herrando 2001; Fraterrigo and Wiens 2005; Glennon and Porter 2005), and density of buildings (Fraterrigo and Wiens 2005; Friesen *et al.* 1995). Landscape modification and diversity of habitats for various life forms, makes urban areas a priority area for conservation (Miller and Hobbs 2002).

MATERIAL AND METHODS

Study Area

Tiruchirappalli, one of the southernmost cities of India, is a historical city. With an area of 4,404 sq. km, it is the fourth largest city in Tamil Nadu, located at the geographic

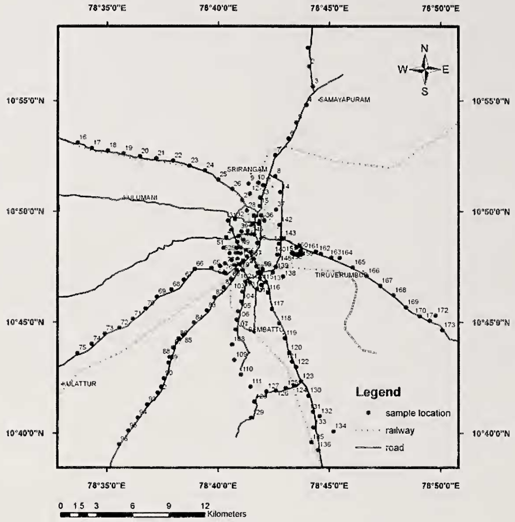

Fig. 1: Sampling points along an urban-rural gradient

centre of the state (10°-11°30' N; 77°45'-78°50' E). The population of the city in 2009 was 829,537. The city lies along the rivers Cauvery and Coleeron, witnessing a high rate of urban agglomeration. It has a number of disconnected hills, among which Pachamalai Hill is the most important, located in the Sengattupatti reserve. The district is agriculturally rich due to its fertile land and perennial rivers. The vegetation is mainly Tropical Dry Deciduous forest and Tropical Thorn forest. The River Cauvery with its numerous distributaries enables extensive paddy cultivation throughout the year. Tiruchirappalli is also among the important industrial cities in Tamil Nadu, with BHEL and HAPP as the major manufacturing units. It is also a major pilgrimage destination with centuries old temples being the major attraction for tourists and a unique habitat for a large number of resident birds. Urbanisation and industrialisation have triggered infrastructure expansion, mushrooming of residential complexes and other commercial developments, leading to large-scale landscape alterations, including changes in seasonal wetlands. These altered landscapes are likely to mould bird species composition and their habitats.

Methodology

Sampling was carried out from October 2010 to September 2011, through 151 point counts to study the effect of landscape changes on species richness and abundance of birds. Sampling points were selected within the city and along the urban-rural gradient. 80 sampling points were selected in the urban, 17 in the suburban and 54 in the rural matrix. At each point, birds were identified and enumerated within 25 m radius for 10 minutes, by the point count method (Bibby *et al.* 2000). The sampling points were visited from 06:00 to 09:00 hrs every month to record bird abundance and richness. All the sampling points within the urban boundary were at distances of 500 m, while along the urban to rural gradient, they were located at a distance of 800 m to 1 km. The points were marked using GPS on eight different roads diverging from the city covering a total area of 900 sq. km (Fig. 1). Survey was avoided on rainy and windy days. The bird species recorded were divided into six foraging guilds: carnivore, granivore, frugivore, insectivore, omnivore, and nectarivore. To evaluate how habitat fragmentation in the urban areas and along the urban-rural gradient affected species composition, bird

Fig. 2: Species abundance along an urban-rural gradient

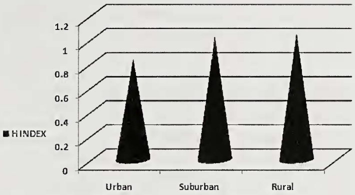

Fig. 3: Diversity index along an urban-rural gradient

community structure and taxonomic composition was studied in various landscapes, like commercial, residential, commercial-residential, agriculture, wastelands, wetlands, and plantations.

Data Analysis

Shannon Wiener species diversity index (Magurran 2004) was calculated within various urban landscapes along the gradient. Niche breadth was calculated to find out the range of resources utilised along the axis (Morin 1999). Species richness, species abundance (Fig. 2), and species evenness were also calculated for different landscapes. The similarity of bird assemblages occupying different landscapes was quantified by Percent of Similarity given by Bray and Curtis (1957). ANOVA recorded the significant difference in diversity indexes of species occupying different landscapes.

RESULTS

A total of 140 species, belonging to 59 families, were recorded during the study with a pooled diversity index of H' = 0.9 (Table 1). The diversity index of rural locations was higher followed by suburban and urban (Fig. 3). The results showed significant difference in the diversity indexes of species occupying the urban-rural gradient (F = 36.76, P = 0.000). Niche breadth did not vary significantly along the gradient (F = 1.43, P = 0.239). Classification of birds based on their trophic status showed a higher density of omnivores (43%) occupying the urban matrix, followed by carnivores (25%), insectivores (17%), nectarivores (8%), granivores (2%), and frugivores (1%). The omnivorous species that were abundant in urban areas were *Milvus migrans*, *Turdoides affinis*, and *Corvus splendens*.

Table 1: Comparison of different indices between urban, suburban, and rural landscapes

Landscapes	Diversity Index	Species Richness	Niche breadth	Species Evenness
Urban	0.82	67	0.22	0.66
Suburban	1.02	85	0.10	0.70
Rural	1.08	137	0.20	0.75

Species richness varied from urban to rural locations, being the highest in the rural matrix (137 species), followed by suburban (85 species), and urban (67 species). The percentage of taxonomic similarity between species occupying the urban and rural landscapes is the lowest at 59%; 72% between urban and suburban; and 63% between suburban and rural.

Along the urban-rural gradient, agricultural landscapes and wetlands are the most preferred habitat for birds, and Eucalyptus plantations are the least preferred. In urban areas, higher abundance of birds was found in locations that had a matrix of residential-commercial land use, rather than purely residential or purely commercial. Agricultural landscapes recorded higher density of insectivores, and wetlands were dominated by Ardeidae species, such as Pond herons (*Ardeola grayii*) and egrets (*Egretta intermedia*, *Egretta garzetta*, and *Bubulcus coromandus*). Diversity index was highest during the southwest monsoon in all landscapes, as seasonal wetlands harbour large numbers of species during the monsoon (Fig. 4). Native tree species *Azadirachta indica*, *Tamarindus indica*, *Ficus benghalensis*, and *Ficus religiosa* were found to harbour a large number of bird species in the urban areas, and shrubs *Prosopis juliflora* and the reed *Typha* provide good habitat

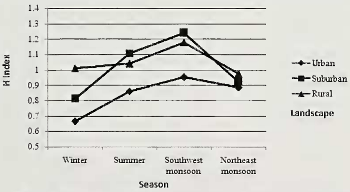

Fig. 4: Scale of diversity among seasons in different landscapes

Table 2: List of bird species recorded based on their foraging guild

Species	Family	Foraging Guild	Species	Family	Foraging Guild
Accipiter badius	Accipitridae	Carnivore	*Egretta garzetta*	Ardeidae	Carnivore
Accipiter nisus	Accipitridae	Carnivore	*Elanus caeruleus*	Accipitridae	Carnivore
Acridotheres tristis	Sturnidae	Omnivore	*Eremopterix griseus*	Alaudidae	Carnivore
Acrocephalus agricola	Acrocephalidae	Insectivore	*Eudynamys scolopaceus*	Cuculidae	Omnivore
Acrocephalus dumetorum	Acrocephalidae	Insectivore	*Euodice malabarica*	Estrildidae	Granivore
Actitis hypoleucos	Scolopacidae	Carnivore	*Francolinus pictus*	Phasianidae	Omnivore
Aegithina tiphia	Aegithinidae	Insectivore	*Francolinus pondicerianus*	Phasianidae	Omnivore
Alauda gulgula	Alaudidae	Omnivore	*Fulica atra*	Rallidae	Omnivore
Alcedo atthis	Alcedinidae	Carnivore	*Galerida cristata*	Alaudidae	Insectivore
Amaurornis phoenicurus	Rallidae	Omnivore	*Gallicrex cinerea*	Rallidae	Omnivore
Ammomanes phoenicura	Alaudidae	Insectivore	*Gallinula chloropus*	Rallidae	Omnivore
Anas platyrhynchos	Anatidae	Omnivore	*Gelochelidon nilotica*	Sternidae	Carnivore
Anas poecilorhyncha	Anatidae	Granivore	*Gracupica contra*	Sturnidae	Omnivore
Anas querquedula	Anatidae	Carnivore	*Halcyon smyrnensis*	Halcyonidae	Carnivore
Anas strepera	Anatidae	Granivore	*Haliastur indus*	Accipitridae	Omnivore
Anastomus oscitans	Ciconiidae	Carnivore	*Hierococcyx varius*	Cuculidae	Carnivore
Anthus richardi	Motacillidae	Insectivore	*Himantopus himantopus*	Recurvirostridae	Carnivore
Anthus rufulus	Motacillidae	Insectivore	*Hirundo rustica*	Hirundinidae	Insectivore
Apus nipalensis	Apodidae	Insectivore	*Hydrophasianus chirurgus*	Jacanidae	Omnivore
Egretta alba	Ardeidae	Carnivore	*Ixobrychus cinnamomeus*	Ardeidae	Carnivore
Ardea cinerea	Ardeidae	Carnivore	*Lanius cristatus*	Laniidae	Insectivore
Ardea purpurea	Ardeidae	Carnivore	*Leptocoma zeylonica*	Nectariniidae	Nectarivore
Ardeola grayii	Ardeidae	Carnivore	*Lonchura atricapilla*	Estrildidae	Granivore
Artamus fuscus	Artamidae	Insectivore	*Lonchura punctulata*	Estrildidae	Granivore
Athene brama	Strigidae	Carnivore	*Lonchura striata*	Estrildidae	Granivore
Bubulcus coromandus	Ardeidae	Carnivore	*Megalaima haemacephala*	Megalaimidae	Omnivore
Butorides striata	Ardeidae	Carnivore	*Megalurus palustris*	Locustellidae	Insectivore
Calandrella brachydactyla	Alaudidae	Insectivore	*Merops leschenaulti*	Meropidae	Insectivore
Caprimulgus asiaticus	Caprimulgidae	Insectivore	*Merops orientalis*	Meropidae	Insectivore
Hirundo daurica	Hirundinidae	Insectivore	*Merops philippinus*	Meropidae	Insectivore
Centropus bengalensis	Cuculidae	Omnivore	*Egretta intermedia*	Ardeidae	Carnivore
Centropus sinensis	Cuculidae	Carnivore	*Metopidius indicus*	Jacanidae	Carnivore
Ceryle rudis	Ceryiidae	Carnivore	*Milvus migrans*	Accipitridae	Omnivore
Charadrius dubius	Charadriidae	Carnivore	*Mirafra affinis*	Alaudidae	Insectivore
Ciconia episcopus	Ciconiidae	Carnivore	*Mirafra cantillans*	Alaudidae	Insectivore
Cinnyris asiaticus	Nectariniidae	Nectarivore	*Mirafra erythroptera*	Alaudidae	Insectivore
Circus macrourus	Accipitridae	Carnivore	*Motacilla cinerea*	Motacillidae	Carnivore
Cisticola juncidis	Cisticolidae	Insectivore	*Motacilla madaraspatensis*	Motacillidae	Insectivore
Clamator jacobinus	Cuculidae	Omnivore	*Muscicapa dauurica*	Muscicapidae	Insectivore
Columba livia	Columbidae	Omnivore	*Mycteria leucocephala*	Ciconiidae	Carnivore
Copsychus saularis	Muscicapidae	Omnivore	*Cinnyris lotenius*	Nectariniidae	Nectarivore
Coracias benghalensis	Coraciidae	Omnivore	*Nycticorax nycticorax*	Ardeidae	Carnivore
Coracina melanoptera	Campephagidae	Insectivore	*Oriolus oriolus*	Oriolidae	Omnivore
Corvus macrorhynchos	Corvidae	Omnivore	*Orthotomus sutorius*	Cisticolidae	Insectivore
Corvus splendens	Corvidae	Omnivore	*Passer domesticus*	Passeridae	Granivore
Cuculus micropterus	Cuculidae	Omnivore	*Pavo cristatus*	Phasianidae	Omnivore
Cypsiurus balasiensis	Apodidae	Insectivore	*Pericrocotus cinnamomeus*	Campephagidae	Insectivore
Dendrocitta vagabunda	Corvidae	Omnivore	*Phalacrocorax carbo*	Phalacrocoracidae	Carnivore
Dendrocygna javanica	Cuculidae	Granivore	*Phalacrocorax fuscicollis*	Phalacrocoracidae	Carnivore
Dicaeum agile	Dicaeidae	Nectarivore	*Phalacrocorax niger*	Phalacrocoracidae	carnivore
Dicaeum erythrorhynchos	Dicaeidae	Nectarivore	*Phylloscopus affinis*	Phylloscopidae	Insectivore
Dicaeum minullum	Dicaeidae	Nectarivore	*Phylloscopus fuscatus*	Phylloscopidae	Insectivore
Dicrurus aeneus	Dicruridae	Omnivore	*Phylloscopus trochiloides*	Phylloscopidae	Insectivore
Dicrurus caerulescens	Dicruridae	Insectivore	*Plegadis falcinellus*	Threskiornithidae	Carnivore
Dicrurus macrocercus	Dicruridae	Omnivore	*Ploceus philippinus*	Ploceidae	Omnivore
Dinopium benghalense	Picidae	Omnivore	*Porphyrio porphyrio*	Rallidae	Carnivore

Table 2: List of bird species recorded based on their foraging guild (*contd.*)

Species	Family	Foraging Guild	Species	Family	Foraging Guild
Porzana fusca	Rallidae	Omnivore	*Temenuchus pagodarum*	Sturnidae	Omnivore
Prinia inornata	Cisticolidae	Insectivore	*Sturnus roseus*	Sturnidae	Omnivore
Prinia socialis	Cisticolidae	Insectivore	*Surniculus lugubris*	Cuculidae	Omnivore
Psittacula krameri	Psittacidae	Frugivore	*Tachybaptus ruficollis*	Podicipedidae	Carnivore
Pycnonotus cafer	Pycnonotidae	Omnivore	*Tephrodornis pondicerianus*	Prionopidae	Insectivore
Pycnonotus luteolus	Pycnonotidae	Omnivore			
Recurvirostra avosetta	Recurvirostridae	Carnivore	*Terpsiphone paradisi*	Monarchidae	Insectivore
Saxicola caprata	Muscicapidae	Insectivore	*Tringa stagnatilis*	Scolopacidae	Insectivore
Saxicoloides fulicatus	Muscicapidae	Omnivore	*Turdoides affinis*	Timaliidae	Omnivore
Streptopelia chinensis	Columbidae	Omnivore	*Tyto alba*	Tytonidae	Carnivore
Sterna hirundo	Sternidae	Carnivore	*Upupa epops*	Upupidae	Omnivore
Streptopelia senegalensis	Columbidae	Omnivore	*Vanellus indicus*	Charadriidae	Carnivore
Streptopelia decaocto	Columbidae	Granivore	*Vanellus malabaricus*	Charadriidae	Carnivore
Streptopelia orientalis	Columbidae	Omnivore	*Zoothera citrina*	Turdidae	Omnivore

for *Prinia socialis*, *Phylloscopus trochiloides*, *P. affinis*, *Orthotomus sutorius* and *Streptopelia chinensis*.

Along the urban matrix, species concentrate more in the urban fringe as it provides a unique corridor and varied landscapes for different species of birds. Among urban birds, the House Sparrow *Passer domesticus* was the most effected by urbanisation. House Sparrow populations were recorded in 12 urban (Fig. 4), 4 suburban and 20 rural locations. The highest population of House Sparrow was recorded in the suburban regions of Tiruchirappalli, in and around areas of Panjapur along the Madurai bypass. Along the gradient, House Sparrows were mostly seen associated with houses with tiled and thatched roofs, in and around rice mills and agricultural landscapes. The mean population of House Sparrow recorded was urban 9, suburban 114, and rural 36.

DISCUSSION

The results show significant difference in the diversity indexes of species occupying the urban-rural gradient. This

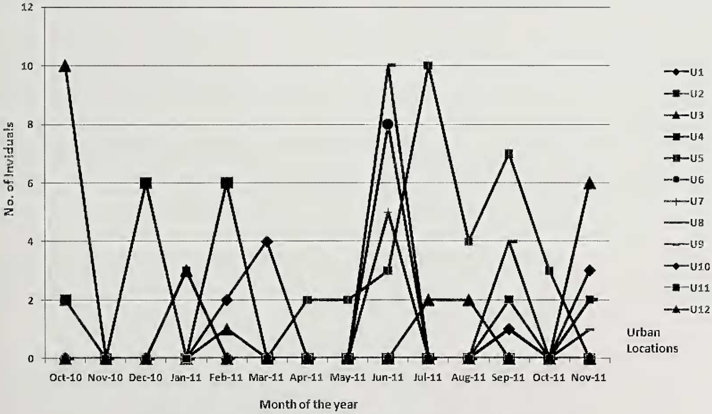

Fig. 5: House Sparrows inhabiting 12 selected locations within the urban landscape

Fig. 6: Nesting of House Sparrows in holes in walls of highway flyovers

can be attributed to the varied landscapes and land use patterns available to birds including agriculture fields, wetlands, wastelands, and plantations. Though diversity is less in urban areas, the abundance of species occupying the urban matrix is higher and increases with urbanisation and is in accordance with other studies (Beissinger and Osborne 1982; Chace and Walsh 2006; Clergeau *et al.* 1998; Emlen 1974; Shochat 2004). Omnivorous species show higher abundance in the urban matrix, leaving less resources to birds from other foraging guilds. Diversity reached a peak at moderate levels of urbanisation and this was revealed in other studies (Blair 1996; 2001; Crooks *et al.* 2004; Jokimäki and Suhonen 1993). But, there was no significant difference in niche breadth of birds occupying different landscapes along an urban-rural gradient, as species tend to exploit a wider area based on resource availability in the urban, suburban, and rural regions. Higher abundance of omnivorous species in urban settings can be correlated to the abundant resources and less predation in the urban matrix, which is supported by several studies (Beissinger and Osborne 1982; Chace and Walsh 2006; Emlen 1974; Kluza *et al.* 2000; Lancaster and Rees 1979; Mills *et al.* 1989). Species diversity in the urban landscape is significantly composed by the edge species like Black Drongo, Indian Roller, Indian Pond-Heron, Great Egret, Little Egret, Eastern Cattle-Egret, Indian Bush Lark that occupy the urban fringes. This study proves that urbanisation has a negative impact on species richness, and is supported by other studies by Stratford and Robinson (2005).

Among the common urban birds, *Passer domesticus* is the most affected, with only a few individuals inhabiting select locations within the city. Their decline can be attributed to loss of food due to modernised granaries, decline of insect prey and most importantly loss of nesting sites. Although decline is noticed overall in the study area, a few sparrow friendly habitats occur along the urban fringes and rural matrix, particularly in the proximity of rice mills, thatched huts, and more interestingly in drainage holes of highway flyovers in the district (Figs 5 & 6). In the district, the highest population of *Passer domesticus* was recorded along the Madurai bypass (Panjapur) and can be attributed to large scale cultivation of paddy and rice mills in the area. Large scale habitat alteration due to changing land use patterns as a result of urbanisation and waning paddy cultivation the world over is a cause of concern for declining House Sparrow populations.

CONCLUSION

In Tiruchirappalli, bird species diversity increases from more to less urbanised centres (Clergeau *et al.* 1998; McKinney 2002). Though urban landscapes are less species diverse, they too play a crucial role in conserving biodiversity as they are 'Species Abundant Zones'. City planners and urban foresters should incorporate the concept of 'Urban Bird Reserve' along urban fringes into urban landscape planning. Protecting the green cover, conserving water bodies, preserving dead trees, constructing ecofriendly architecture, and well-designed urban landscaping will help in protecting and reversing the decline of urban bird species.

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